The evolution of urethral stricture and urethroplasty practice over 15 years: A single-center, single-surgeon, 1319 urethroplasty analysis

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Abstract

Introduction: The management of urethral stricture has evolved over the last several decades. We sought to analyze urethral stricture and urethroplasty trends at a tertiary referral center over a 15-year period.

Methods: Patients undergoing urethroplasty by a single surgeon from August 2003 to July 2018 were analyzed. Patient demographics, urethroplasty techniques, and outcomes were collected in a prospectively maintained database and were categorized into three five-year tertiles based on date of surgery. These tertiles were subsequently retrospectively analyzed for trends and changes in practice.

Results: A total of 1319 urethroplasties were completed over the study period. During the first five years (T1), 299 urethroplasties were performed, with 431 and 589 performed in T2 and T3, respectively. Mean overall patient age was 46.8 years, which increased significantly over time (p<0.001). Idiopathic strictures were most common (n=516, 39.1%) and unchanged over time, while proportionately radiation-induced strictures increased (n=9, 3.0% [T1], n=22, 5.1% [T2], n=51, 8.7% [T3]; p=0.001) as did iatrogenic and lichen sclerosus strictures. Mean stricture length (4.7 cm [T1], 4.8 cm [T2], 4.0 cm [T3]; p<0.001) and the mean number of prior endoscopic procedures (3.4 [T1], 3.9 [T2], and 2.5 [T3]; p<0.001] decreased over time. Single-stage urethroplasty with buccal mucosa was the most common technique performed (n=656, 49.7%) that increased in prevalence (p=0.009), while both flap and staged techniques decreased (p=0.008, p=0.004, respectively). Overall success rate was 90.1% (n=1106), which improved significantly with time (n=248, 86.7% [T1], n=359, 90.0% [T2], n=499, 93.4% [T3]; p=0.001).

Conclusions: We observed that patients and treatment of urethral stricture evolved over 15 years in practice, with an increase in patient age, radiation, and iatrogenic and lichen sclerosus strictures, while demonstrating a decrease in stricture length and the number of prior endoscopic procedures performed. Increased use of single-stage urethroplasty using buccal mucosa was observed, which may have contributed to an increase in urethroplasty success over time.

KEY MESSAGES

- Urethroplasty practice has evolved over the last 15 years likely in response to urological society guidelines, innovations in surgical technique, and locoregional referral patterns.
- With time, urethroplasty volume increased, along with changes in patient demographics, stricture etiology, and complexity.
- In the last five years, stricture length decreased, along with a reduction in the number of endoscopic procedures performed prior to referral, with a concurrent increase in urethroplasty success.
- There has been a significant trend toward widespread adoption of single-stage urethroplasty with buccal mucosa at the expense of staged and penile fasciocutaneous flap reconstruction.

Introduction

The management of urethral strictures has evolved dramatically over the last several decades.[1] This has been related to several innovations in the field of reconstructive urology, particularly involving urethroplasty technique.[2] Historically, despite poor long-term success rates, especially in the setting of recurrent stricture, patients were (and still are) most commonly managed endoscopically with either dilation or urethrotomy.[3-5] While offering temporary improvement in lower urinary obstruction associated with urethral stricture, repeat endoscopic treatments can increase the complexity of urethral stricture and urethroplasty.[6,7]

Given the low rates of cure with repeat endoscopic treatment, multiple urological guidelines within the last 5–7 years have recommended urethroplasty after failure of endoscopic treatment or in patients at high risk of stricture recurrence.[8-10] These recommendations, in theory, should result in a reduction in the use of repeat endoscopic treatment.[4,5]

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In addition to advances in urethroplasty and guideline recommendations, urethroplasty practice can also be shaped by locoregional referral patterns. For example, healthcare in western Canada serves an estimated population of 11 million people in a geographic area of over 6.3 million km^2.[11] This region is 2 million km^2 larger than the European Union with 40 times less the population.[12] Historically, only a small number of centers in this catchment routinely performed urethroplasty, leading to a somewhat captive patient audience for urethroplasty, while simultaneously providing a geographic barrier to referral. Nonetheless, reconstructive urology practice within this captive geographical zone may uniquely reflect changes in the evolution of urethroplasty practice and stricture management over time.

We hypothesize that there will be a shift in patient demographics and stricture complexity as reconstructive urology practices evolve and individual surgical experience grows. We aimed to analyze trends in patient presentation and reconstructive practice in all patients undergoing urethroplasty at a single-center over a 15-year period.

Methods

Patients undergoing urethroplasty by a single surgeon from August 2003 to July 2018 were included in this study. Patient demographics, clinical presentation, surgical procedure, and outcomes data were collected in a prospectively maintained database. All patients undergoing urethroplasty during this time were eligible for study inclusion. No specific exclusion criteria were applied and no outliers were omitted.

A retrospective analysis categorized patients into three, approximately five-year tertiles based on date of surgery (T1 = August 2003 to July 2008; T2 = August 2008 to May 2013; T3 = June 2013 to July 2018). These tertiles were compared and trends over time were analyzed with respect to the variables of patient age, stricture etiology, stricture length, number of prior endoscopic treatments, urethroplasty techniques, and anatomic surgical success. The ability to pass a 16 Fr flexible videocystoscope at approximately six months postoperatively was defined as anatomic success.

Patients were again evaluated at 18 months postoperatively; no evidence of recurrent stricture at this timepoint defined overall urethroplasty success, which was used for comparison between cohorts. Paired t-tests were performed when we sought to compare continuous variables to earlier cohorts (T1 and T2) and to the surgeon's current state of practice (T3). Matched analysis of variance (ANOVA) was used when continuous variables were compared across all three cohorts simultaneously. Lastly, Chi-squared analysis was used to compare categorical variables between tertiles. A predetermined alpha value for significance was set at 0.05. Statistical analysis was performed using the IBM SPSS statistical software package.

Results

A total of 1319 urethroplasties were completed over the study period. During the first five years (T1), 299 urethroplasties were performed, while 431 and 589 were performed in T2 and T3, respectively (Figure 1A). Mean overall patient age was 46.8 years and this increased significantly over time ($p<0.001$) (Figure 1B). Mean stricture length was 4.4 cm and this was found to decrease over time (4.7 cm [T1], 4.8 cm [T2], 4.0 cm [T3]; $p<0.001$) (Figure 1C) with a previously failed endoscopic treatment alone (n=1172, 88.9%), while 249 patients (18.9%) had additionally undergone a prior open reconstruction. Overall, the mean number of prior endoscopic procedures decreased significantly over time (3.4 [T1], 3.9 [T2], 2.5 [T3]; $p<0.001$) (Figure 1D).

Most patients presented with an idiopathic cause of their stricture (n=516, 39.1%) and this did not change over time (Table 1). Trauma was the second most common etiology (n=262, 19.9%) but decreased significantly over time ($p<0.001$). Radiation-induced strictures significantly increased over time (n=9, 3.0% [T1], n=22, 5.1% [T2], n=51, 8.7% [T3]; $p=0.001$), as did iatrogenic and lichen sclerosus-associated strictures.

Regarding urethroplasty technique, single-stage urethroplasty with buccal mucosa was most commonly performed (n=656, 49.7%) and increased in prevalence over time ($p=0.009$) (Table 2). Flap and staged techniques decreased over time ($p=0.008$, $p=0.004$, respectively). The remaining techniques did not vary.

Finally, the overall success rate at 18 months was 90.1% (n=1106). This appeared to improve significantly with time (n=248, 86.7% [T1], n=359, 90.0% [T2], n=499, 93.4% [T3]; $p=0.001$) (Figure 2).

Discussion

The evolution and refinement of urethroplasty over the last 15 years has been reflected in this analysis of trends in a single-center, single-surgeon, retrospective cohort study. Through establishing three discrete tertiles, we were able to portray interval improvements in urethroplasty success while simultaneously showing both expected and unexpected changes in stricture length, etiology, and complexity.

Over the course of the study period, urethroplasty volume grew progressively. This may be related to the evolution of a tertiary referral center where, with experience and reputation, an increasing number of patients are referred for genitourinary reconstruction. Alternately, this trend could also represent a general shift in dedicated sub-specialization happening throughout the field of urology.[13] Regardless, of the exact reason for the increase in urethroplasty volume, this trend mirrored a concurrent steady increase in anatomically defined surgical success.

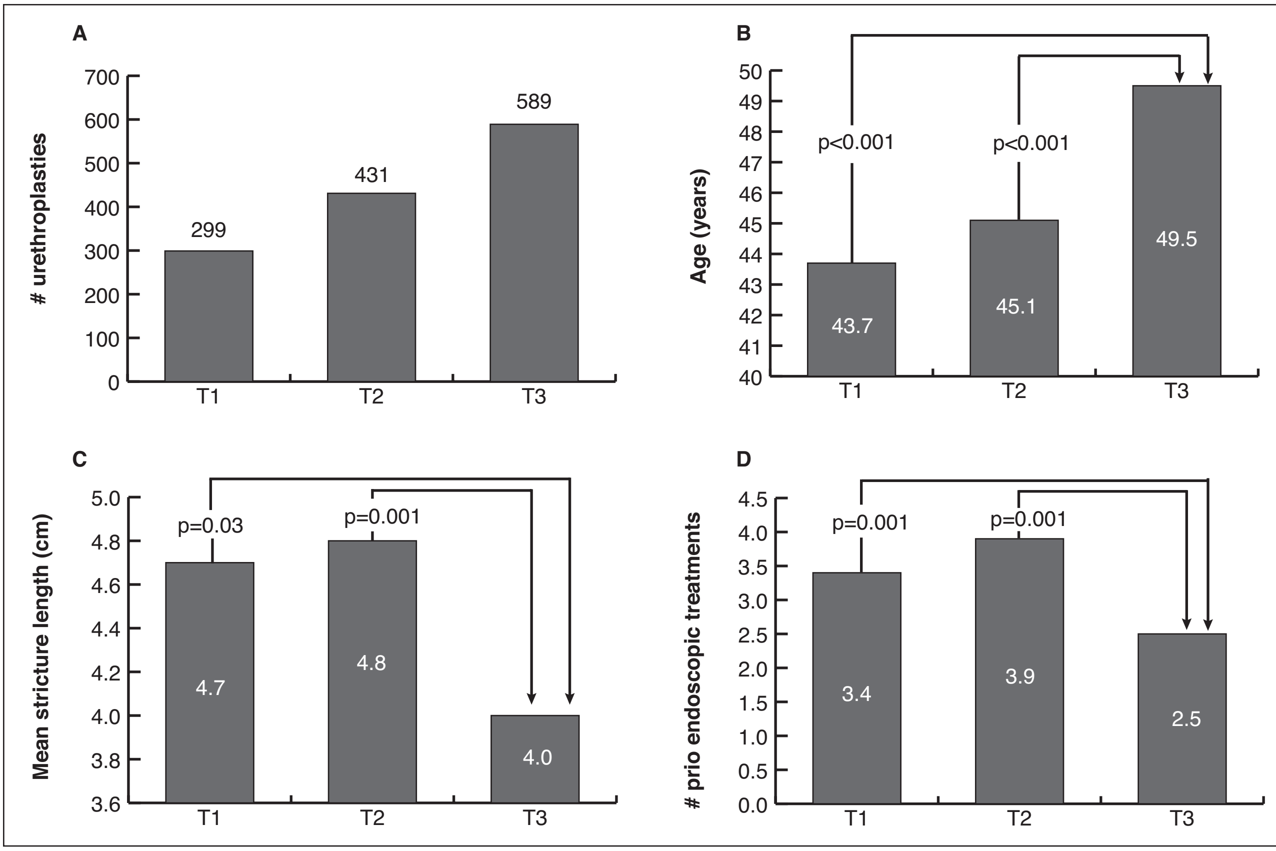

Figure 1. Bar charts depicting trends in **(A)** urethroplasty volume, **(B)** patient age, **(C)** stricture length, and **(D)** number of prior endoscopic treatments over the 15-year study period. **(A)** Number of urethroplasties performed per tertile with increase over the study period. **(B)** Patient age (in years) at the time of urethroplasty with significant differences between each tertile. **(C)** Stricture length (cm) per tertile with significant difference between the most recent and preceding two tertiles. **(D)** Number of prior endoscopic procedures (n) per tertile with significant differences between most recent and preceding two tertiles.

Overall success of urethroplasty over the 15-year period, defined by a cystoscopic endpoint, was 90.1%. Broadly reported success rates for the index stricture patient undergoing standard buccal mucosa graft urethroplasty have been estimated across multiple series to be at least 80%.[8,9] In our center, from the outset, this threshold has been exceeded across all urethroplasty subjects, increasing from 86.7% in the first five years to 93.4% in the most recent tertile. Urethroplasty competency has been estimated to occur at around 100 cases, which seems plausible given that this threshold was surpassed in all five-year tertiles;[14] however, even past this threshold, it is thought that the surgical learning curve of urethroplasty may continue to improve past 600 cases.[15]

In addition to surgical experience, the progressive improvement observed in our practice may be indicative of continued refinement of surgical technique. One component of this refinement is the continued use and broadened application of single-stage buccal mucosal grafts even in the penile urethra.[16] Both local tissue flaps and staged

Table 1. Stricture etiology by stratified 5-year tertiles

Etiology	T1	T2	T3	p	OR	95% CI
Idiopathic	113 (39.8%)	169 (39.2%)	234 (39.7%)	0.59	1.04	0.90–1.20
Trauma	92 (30.8%)	88 (20.4%)	82 (13.9%)	**<0.001***	0.60	0.51–0.72
Lichen sclerosus	23 (7.7%)	50 (11.6%)	74 (12.6%)	**0.04***	1.27	1.01–1.59
Radiation	9 (3.0%)	22 (5.1%)	51 (8.7%)	**0.001***	1.75	1.27–2.42
Hypospadias	34 (11.4%)	41 (9.5%)	64 (10.9%)	0.95	0.99	0.80–1.24
Iatrogenic	21 (7.0%)	47 (10.9%)	73 (12.4%)	**0.02***	1.32	1.05–1.67
Inflammation/infection	7 (2.3%)	14 (3.3%)	8 (1.4%)	0.21	0.75	0.47–1.17

*p<0.05. CI: confidence interval; OR: odds ratio.

Table 2. Urethroplasty technique trends per tertile over the 15-year study period						
Urethroplasty technique	**T1**	**T2**	**T3**	**p**	**OR**	**95% CI**
Anastomotic	96 (32.1%)	106 (24.6%)	171 (29.0%)	0.59	0.96	0.82–1.12
Buccal mucosa graft onlay	130 (34.4%)	214 (49.7%)	312 (53.0%)	**0.009***	1.20	1.05–1.38
Fasciocutaneous flap onlay	18 (6.0%)	36 (8.3%)	16 (2.7%)	**0.008***	0.67	0.50–0.90
Staged/urethrostomy	50 (16.7%)	63 (14.6%)	60 (10.2%)	**0.004***	0.75	0.61–0.91
Other	5 (1.7%)	12 (2.8%)	20 (3.4%)	0.15	1.39	0.89–2.16

*p<0.05. CI: confidence interval; OR: odds ratio.

approaches have experienced a significant decline at our center. This shift away from flaps and staged operations has likely been driven by similar-to-inferior success rates, higher cumulative postoperative morbidity, improved patient selection, and patient preference.[17,18]

Improved surgical success at our center may have led to a widening of the referral base, with a subsequent increase in urethroplasty volume or vice versa. Nonetheless, this increase in patient volume appears to be associated with increasingly complex patients, as manifested by an increase in treatment of older patients with more challenging stricture etiologies. In our study, patient age at the time of urethroplasty steadily increased across tertiles by an absolute total of nearly six years. Although age has not been shown to definitively impact urethroplasty success rates, it does bring with it potential increased comorbidities and greater perioperative risk.[19,20]

In terms of stricture etiology, idiopathic strictures remained the most common cause of stricture throughout the 15-year period but other etiologies, such as lichen sclerosus, iatrogenesis, and radiation increased in relative amounts. These etiologies are generally regarded as more challenging to treat. For example, radiation-associated urethral stenoses are commonly associated with a myriad of other genitourinary adverse events, such as sphincteric weakness, pain, radiation cystitis, refractory lower urinary tract symptoms, fistulae, and prostatic necrosis, thereby contributing to greater surgical complexity.[21] These intricacies are mirrored, albeit to a lesser extent, in iatrogenic and lichen sclerosus-associated cases, which are commonly associated with urethroplasty failure and complexity.[22,23] Over time, these older and more challenging patients have composed a greater proportion of the urethroplasty cohort at our center.

Stricture length is interestingly one component of stricture complexity that has decreased over time, changing from 4.7 cm to 4.0 cm. This potentially reflects the continued movement away from endoscopic management of strictures, particularly in the recurrent setting.[8-10] The International Consultation on Urological Diseases consultation of urethral stricture, as well as both the American Urological Association and Canadian Urological Association guidelines endorse that repeat endoscopic treatment may increase stricture complexity, urethroplasty complexity, and the rate of stricture recurrence.[6-10] A recent randomized study evaluating urethroplasty vs. endoscopic urethrotomy in the recurrent setting found that although both interventions yield significantly improved symptoms, open repair has the more durable response and once again, requires less re-intervention.[24]

In our findings, patients in the third most recent tertile underwent significantly fewer attempts at endoscopic management and as a result, may have avoided iatrogenic increase in stricture length and complexity. This more contemporary trend has been observed elsewhere.[5] Despite a decline in the number of prior endoscopic treatments, the majority of patients still futilely undergo repeat endoscopic attempts prior to undergoing definitive urethroplasty. Possibly, although we are unable to prove this with our current results, the decrease in stricture length could also be accounted for by refinements in preoperative staging. Improved retrograde urethrography resolution and better incorporation of cystoscopic findings may lend to less overestimation of stricture length.[25]

Limitations

Despite the use of prospective data collection, our study methodology involved retrospective analysis, potentially introducing bias into our conclusions. Additionally, there may have been a selection bias influencing some of the findings if surgical judgement and decision-making improved

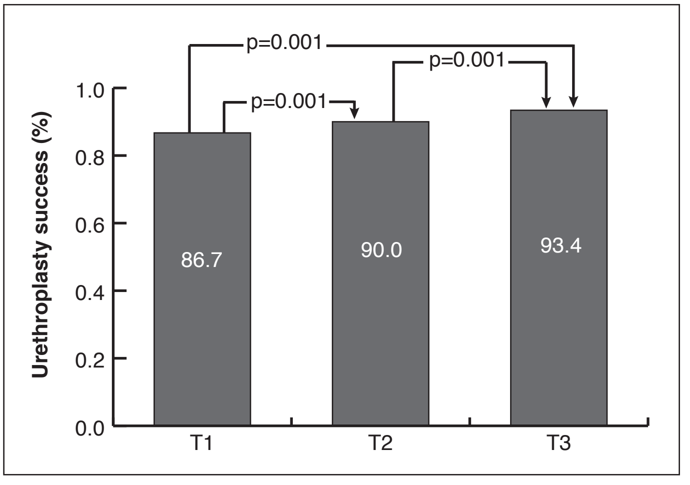

Figure 2. Cystoscopic success rate (%) stratified by tertile demonstrating a significant improvement over the 15-year study period and between tertiles.

over the study period. This would result in demographic changes and improved outcomes independent of referral patterns. The decision to divide the cohorts into tertiles could also be viewed as an arbitrary threshold. Nevertheless, we believe these represent reasonable intervals to evaluate change and growth in one's practice. Despite the retrospective evaluation and the potential confounders this methodology may introduce, it is suitable given the prolonged and unique look this study provides into the maturation and evolution of a single-surgeon's practice.

Conclusions

The surgical treatment of urethral stricture has evolved over the last 15 years and with it, so has the approach to treatment at our center. Increases in patient age, radiation, lichen sclerosus, and iatrogenic strictures have been observed. A decrease in stricture length and a reduction in the number of endoscopic procedures performed prior to referral have also been seen. The increased preference for single-stage urethroplasty with buccal mucosal substitution was observed, likely resulting from the patient-centered evolution of the technique and increasing surgeon's comfort with said modality.

Competing interests: The authors do not report any competing personal or financial interests related to this work.

This paper has been peer-reviewed.

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